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Non-reverberant music for acoustic studies

No. 1969/17

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RESEARCH DEPARTMENT

NON-REVERBERANT MUSIC FOR ACOUSTIC STUDIES

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(PH-33)

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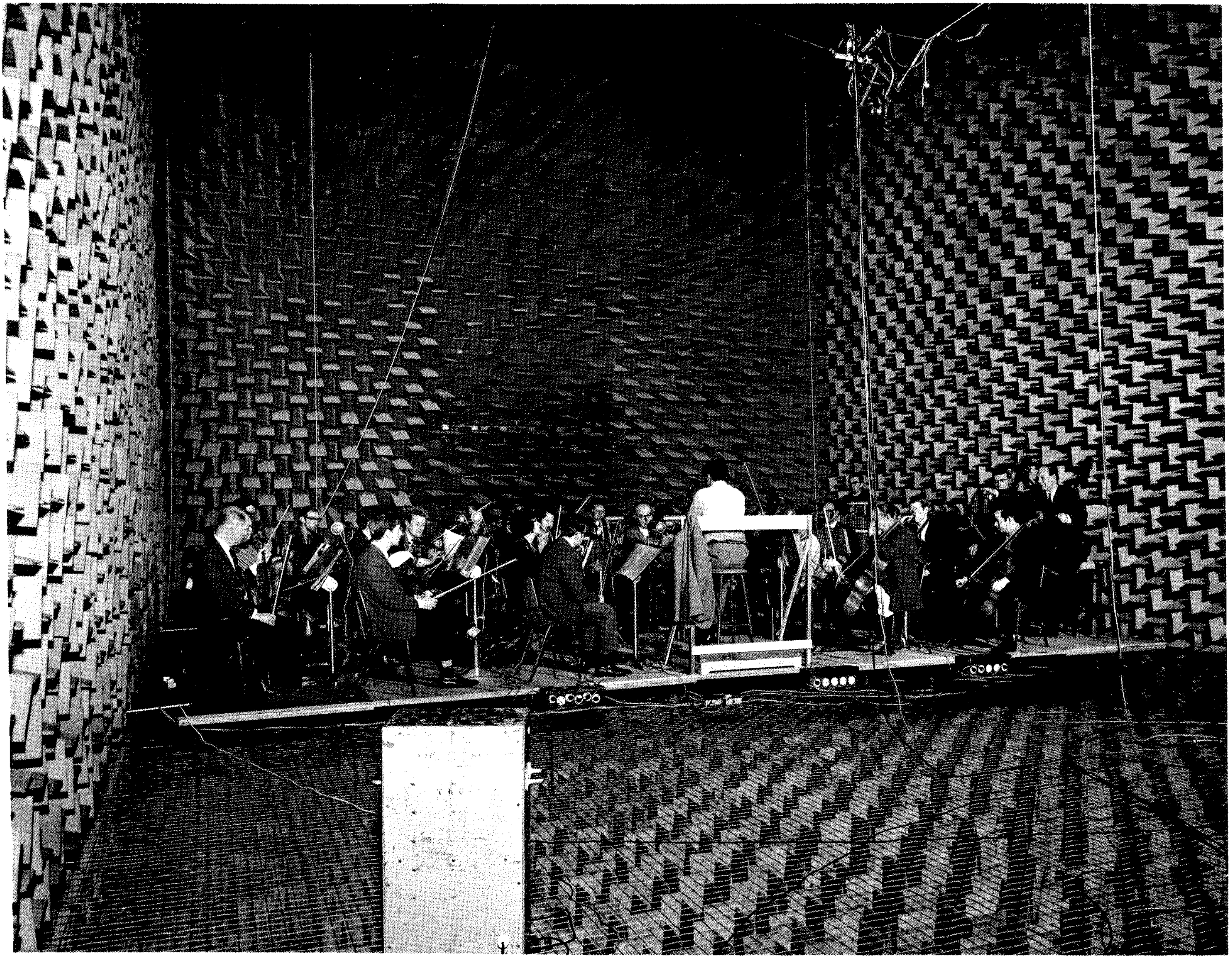

The free-field room at Building Research Station

July 1969

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NON-REVERBERANT MUSIC FOR ACOUSTIC STUDIES

SUMMARY

A music recording session was arranged with a professional orchestra playing in a free-field room; the resulting music is without any natural reverberation, the only reflections being those from the stage on which the orchestra was seated. The music is required for a variety of studies including the acoustic modelling of studios.

1. INTRODUCTION

Research is currently under way in several U.K. research laboratories to which programme material having no reverberation will form an essential contribution; such work includes the BBC Research Department project on Acoustic Modelling. In this project a model of a music studio will be constructed having all the physical characteristics of the structure reduced by a scale factor of $1/n$ and considerable care will be taken to ensure that the materials used in the construction of the model reproduce, at n times the normal frequencies, the acoustic absorption characteristics of the materials which they represent in the full-size studio. Acoustic signals, including programme, will then be reproduced in the model at scaled frequencies, the tape recorder on which the signals are recorded being replayed at n times the recording speed. The ratio of signal wavelength to physical dimensions will thus be the same in the model as in the full-size studio and, within the limitations of the similarity of the radiating transducers to the sources they represent, the acoustic waves will behave similarly in model and studio. The signal, modified by the acoustic characteristics of the model, will be re-recorded at high speed and appraised subjectively or measured objectively by standard techniques on subsequent reproduction at normal speed. This report describes the preparation of a recording of music having no natural reverberation, which will find application in the subjective evaluation of such an acoustic model.

At the Building Research Station of the Ministry of Public Building and Works a continuing programme of work is examining the artificial reverberation system known as assisted resonance. The most common cause of instability in a feedback type of artificial-reverberation system (such as ambiophony) occurs when an irregular response/frequency characteristic of the loop causes oscillation at certain frequencies at an average level of feedback insufficiently great to extend substantially the natural decay time of the auditorium. Assisted resonance eliminates this problem by using a large number of separate channels each operating over a very narrow frequency band; resonators supply the necessary selectivity at each microphone and loudspeaker. Experience has shown that with the channels spaced some 3 Hz apart an acceptable system results. Other research includes model work at Salford University where a 1/10th scale model of the Herculesaal in Munich has been made; the aim here is currently restricted to an evaluation of the subjective importance of early reflections on the acoustic quality of the sound. Within the Institute of Sound and Vibration Research at Southampton University the same problem is being approached in a different way. Observers listening in a free-field room are presented with the programme material direct and through several delaying paths; the amplitudes of the delayed signals can be adjusted by the listeners to achieve the most acceptable condition. At the University of Manchester Institute of Science and Technology experiments which set out to study an ambiophony system have currently been modified to examine an artificial-reverberation system employing a coupled reverberant space. At Bradford University suitable programme material is to be slowed down by a factor of 400 and digitized at a standard sampling rate; a computer will then simulate the reverberation characteristics of a room or hall by adding a desired pattern of reflections (repetitions) and after reconversion to analogue form, the resulting signal will be appraised subjectively.

In view of the demand for suitable programme material in connection with all the above-mentioned research projects, it was suggested (by P.H. Parkin of Building Research Station) that the interested organizations should jointly finance a recording session in which an orchestra would play suitable music in the large free-field room at the Building Research Station. An attempt was made to organize the recording session in 1967, but proved impracticable. However, in late 1968, a successful attempt was made.

2. PRIOR ARRANGEMENTS

2.1. The Site

The free-field room at Building Research Station, completed about 1964, is understood to be the largest in Europe; the usable space within the confines of the wedge absorbing-treatment is 13·4 x 9·2 x 9·8 m and the room is lined with expanded polyurethane foam wedges, each 1·2 m in length. A simple criterion of the effectiveness of such an acoustically-absorbing treatment is the frequency below which the reflection coefficient of the surface rises above 10%; the 'cut off' frequency for this room is 70 Hz.

The orchestra could not be supported on the wire mesh floor which is permanently installed in the room and, therefore, a platform was built, on tubular steel legs, which extended between the foam wedges to the structural floor; in addition, it was braced to the walls at six places. The platform measured 8·5 x 4·9 m and had its surface 0·66 m above the top of the wedges. It was made from blockboard, the thickness varying between 38 mm and 56 mm, and was not covered by absorbing material; the recordings thus correspond to an orchestra on a reflecting platform. (It should be noted that, unlike a conventional auditorium, the platform was not enclosed and this may have affected the radiation from its surface.)

2.2. The Orchestra

The English Chamber Orchestra was considered to be an orchestra of suitable numerical strength with considerable experience of playing in acoustically 'near-dead' conditions, such as are provided by many present-day recording studios. An approach was made to their management and two groups of players were booked for the recording session. These were, first, the Phillip Jones Brass Ensemble, comprising two trumpets, one trombone, one horn and a tuba, and, secondly, the English Chamber Orchestra itself.

2.3. The Programme

Two items from their standard repertoire were to be played by the Brass Ensemble. They were:

Orlando Gibbons, Royal Pavane
Alan Civil, Tarrantango.

Four orchestral items were selected and discussed with the orchestral management. They were intended to give a wide range of orchestral tempi, scoring and styles.

The pieces played were:

Mozart, Symphony in C Major (Jupiter), fourth movement; Molto Allegro
Haydn, Symphony No. 102 in B♭ major, second movement; Adagio
Wagner, Siegfried Idyll; concluding five minutes
Arnold, Sinfonietta for 2 oboes, 2 horns and strings, third movement; Allegro con brio.

Additional material, which was scored for us by the conductor Kenneth Montgomery, included a series of staccato chords, a sustained chord, a series of staccato discords, a sustained discord and an octave chromatic scale.

Table 1 shows the composition of the orchestra for the various works recorded.

TABLE 1

Composition of English Chamber Orchestra

Instrument	Number of Players				
	Mozart	Haydn	Wagner	Arnold	Chords
1st violins	6	6	6	6	6
2nd violins	6	6	6	6	6
Violas	4	4	4	4	4
Cellos	4	4	4	4	4
Basses	2	2	2	2	2
Flute	1	1	1	–	1
Oboes	2	2	1	2	2
Clarinets	–	–	2	–	2
Bassoons	2	2	1	–	2
Horns	2	2	2	2	2
Trumpets	2	2	1	–	2
Tympani	1	1	–	–	1

2.4. Recording Facilities

A stereo mobile sound control-room, tape recorders and the services of recording engineers were provided by the BBC Transcription Recording Unit (T.R.U.).

The microphones included an A.K.G. type C24 coincident-pair microphone from which a stereophonic recording was produced, together with others enabling a monophonic recording to be prepared with characteristics matching the condition selected for the stereophonic recording; these other microphones were an A.K.G. type C28, an S.T. and C. type 4038, and a Sennheiser type MD62. A nominally omnidirectional Brüel and Kjær measurement microphone, 25 mm in diameter was also included.

In practice the C24 microphone was used in a 'cottage-loaf' configuration, a position midway between cardioid and figure-of-eight. This was matched, for the monophonic recording, by a C28 microphone having a cardioid response well maintained over the working frequency range.

The recordings were made on ¼ in. (6·25 mm) BASF LR 56 recording tape using Studer A62 tape recorders.

2.5. Other Facilities

The microphone outputs could be passed through a pair of Grampian spring reverberation units, and fed back to the orchestra through individual sets of headphones. It was arranged that each side of the orchestra had feeds from the corresponding side of the stereo signal, while the conductor was supplied with a feed of the sum of the two sides.

Music stands with lights were borrowed from the Royal Festival Hall.

3. THE SESSION

The recording took place on the afternoon of 30th January 1969; luck was favourable and none of the possible catastrophies envisaged in fact occurred.

The music stands and their associated lighting facilities had been arranged, the microphones had been suspended and the headphone feeds had been distributed on the preceding day. The remainder of the equipment was rigged and adjusted during the morning of 30th January.

After a short period of rehearsal the orchestra chose to play without headphones and the recording proceeded normally with a limited number of re-takes.

At one point in the programme an item was repeated with the entire orchestra wearing headphones, with the result that the ensemble, in so far as this relates to the ability of the orchestra to play together, improved; however, the tonal quality deteriorated. It was reasonable to assume that this was a result of each member of the orchestra having improved audibility of everyone else's playing but reduced ability to hear the quality he (or she) was producing. On reflection, it would seem that an improvement might have resulted from the use of single headphones.

4. ADDITIONAL DATA

A master tape of some 27 minutes duration was prepared. In addition to the musical contribution, pure tones (at octave intervals), together with an octave band of pink noise centred on 500Hz, were radiated from a loudspeaker on the platform at a known level and recorded. The tape concluded with six pistol shots fired in the free-field room, which might prove of value in the measurement of the reverberation time of reverberant systems tested using the recorded material.*

5. CONCLUSIONS

A recording session with a Brass Ensemble and a Chamber Orchestra has been described in which the resulting recordings have no natural reverberation. These will be of great value in the subjective assessment of acoustic models and artificial reverberation systems.

6. ACKNOWLEDGEMENTS

The arrangements for this recording were made in collaboration with Mr. P.H. Parkin of the Building Research Station (Ministry of Public Buildings and Works) and the recording would not have been possible without the use of the B.R.S. free-field room and the associated facilities. Financial sponsorship of the project was partly undertaken by the Universities mentioned in the Introduction and their support is gratefully acknowledged. The Phillip Jones Brass Ensemble and the English Chamber Orchestra are to be congratulated on their ability to play under such difficult acoustical conditions; they co-operated with enthusiasm and interest. Transcription Recording Unit, and particularly John Bower, recorded, edited and copied the music, contributions which were essential to the successful completion of the project.

We are grateful to the Building Research Station for permission to use their photograph of the Orchestra and free-field room as a frontispiece to this report.

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* It should be noted that the reproduction of these pistol shots by loudspeakers will be of limited value owing to their inability, in most cases, to provide sufficient acoustic power.

JMP